

INTERNATIONAL STANDARD

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Plastics — Poly(methyl methacrylate) sheets — Types, dimensions and characteristics —

Part 2 : Melt-calendered extruded sheets

*Plastiques — Plaques en poly(méthacrylate de méthyle) — Types, dimensions
et caractéristiques —*

Partie 2 : Plaques extrudées-calandrées



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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 7823-2 was prepared by Technical Committee ISO/TC 61, *Plastics*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

ISO 7823 consists of the following parts, under the general title *Plastics — Poly(methyl methacrylate) sheets — Types, dimensions and characteristics*:

- *Part 1: Cast sheets*
- *Part 2: Melt-calendered extruded sheets*

Annexes A and B form an integral part of this International Standard.

Plastics — Poly(methyl methacrylate) sheets — Types, dimensions and characteristics —

Part 2 : Melt-calendered extruded sheets

1 Scope and field of application

1.1 This part of ISO 7823 specifies requirements for poly(methyl methacrylate) (PMMA) flat sheets, extruded and melt-calendered from colourless and coloured, transparent, translucent and opaque grades of materials defined in 3.1.

1.2 The thickness range of sheets covered by this part of ISO 7823 is 1,5 to 12 mm.

2 References

ISO 62, *Plastics — Determination of water absorption.*

ISO 75, *Plastics and ebonite — Determination of temperature of deflection under load.*

ISO 178, *Plastics — Determination of flexural properties.*¹⁾

ISO 179, *Plastics — Determination of the Charpy impact strength of rigid materials.*

ISO 291, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 306, *Plastics — Thermoplastic materials — Determination of Vicat softening temperature.*

ISO 489, *Plastics — Determination of the refractive index of transparent plastics.*

ISO 527, *Plastics — Determination of tensile properties.*²⁾

ISO 1133, *Plastics — Determination of the melt flow rate of thermoplastics.*

ISO 1183, *Plastics — Methods for determining the density and relative density of non-cellular plastics.*

ISO 1628-6, *Plastics — Determination of viscosity number and limiting viscosity number — Part 6: Methyl methacrylate polymers.*³⁾

ISO 2039-2, *Plastics — Determination of hardness — Part 2: Rockwell hardness.*

ISO 2818, *Plastics — Preparation of test specimens by machining.*

ISO 2859, *Sampling procedures and tables for inspection by attributes.*

ISO 4582, *Plastics — Determination of changes in colour and variations in properties after exposure to daylight under glass, natural weathering or artificial light.*

ISO 4607, *Plastics — Methods of exposure to natural weathering.*

ISO 4892, *Plastics — Methods of exposure to laboratory light sources.*

ISO 8257-1, *Plastics — Poly(methyl methacrylate) (PMMA) moulding and extrusion materials — Part 1: Designation.*

EN 2155-5, *Measure of the transmittance.*

EN 2155-9, *Determination of haze.*

EN 2155-12, *Determination of coefficient of linear thermal expansion.*

3 Definitions

For the purposes of this part of ISO 7823, the following definitions apply.

3.1 homopolymers and copolymers of methyl methacrylate (MMA): PMMA homopolymers and copolymers of MMA containing at least 80 % (m/m) of MMA and not

1) At present at the stage of draft. (Revision of ISO 178 : 1975.)

2) At present at the stage of draft. (Revision of ISO/R 527 : 1966.)

3) At present at the stage of draft. (Revision of ISO 1233 : 1975.)

more than 20 % (m/m) of acrylic ester or other suitable monomers. They include both unmodified materials and materials containing lubricants, processing aids, UV absorbers, pigments and colourants. They do not include PMMA modified with elastomers (see ISO 8257-1).

3.2 flat PMMA sheets: Sheets with two plane, substantially parallel surfaces.

4 General requirements

4.1 Protection of surface

Unless otherwise agreed upon by the interested parties, the surfaces of the sheet, as delivered, shall be protected by suitable material, for example kraft paper secured with a water-soluble or pressure-sensitive adhesive or a polyethylene film, readily removable without surface contamination or damage.

4.2 Appearance

4.2.1 Surface defects

The sheet shall have a smooth surface. There shall be no surface defects, scratches or marks larger than 5 mm² each anywhere in the sheet.

4.2.2 Inclusion defects

There shall be no bubbles, large inclusions, cracks or other defects that could adversely affect the performance of the sheet in its intended application. There shall be no foreign matter inclusions larger than 4 mm² each anywhere in the sheet.

4.2.3 Classification of defects

The area of defects found in the sheet shall be classified as specified in table 1. Each defect shall be considered separately.

Table 1 — Classification of defects

Classification	Surface defects	Inclusion defects
Negligible	Less than 2 mm ²	Less than 1 mm ²
Acceptable	2 to 5 mm ²	1 to 4 mm ²

4.2.4 Distribution of defects

4.2.4.1 There shall not be a significant (for the application) amount of fine defects, each of which is defined as negligible in table 1, within 1 m² anywhere in the sheet.

4.2.4.2 No defect defined as acceptable in table 1 shall be within 500 mm of another acceptable defect anywhere in or on the sheet.

4.3 Colour

The colour distribution shall be homogenous, unless otherwise specified. Variations in colours shall be agreed between the interested parties.

4.4 Dimensions

The shape of the sheet shall be substantially rectangular or square. The tolerances on squareness shall be agreed upon by the interested parties.

4.4.1 Length and width

The length and width of the sheets shall be agreed upon by the interested parties. For cut sheets, the tolerances for each sheet are specified in table 2.

Table 2 — Tolerance on length and width

Length or width mm	Tolerance mm
Up to 1 000	+3 0
From 1 001 to 2 000	+6 0
From 2 001 to 3 000	+9 0
3 001 and over	+0,3 % 0

4.4.2 Thickness

The thickness tolerance for sheets in the range 1,5 to 2,5 mm shall be ± 10 %; for sheets 3 to 12 mm thick it shall be ± 5 %.

The tolerances apply within each sheet and from sheet to sheet.

4.4.3 Measurements

Measurements of dimensions shall be made at room temperature, except that in case of dispute measurements shall be made under standard conditions, as specified in ISO 291. For measurements made under ambient conditions, due allowance shall be made for dimensional changes due to the differences in temperature and relative humidity between test locations.

5 Basic and optional properties

5.1 Basic properties

The ranges of the values of the basic properties of PMMA melt-calendered extruded sheets are given in table 3.

5.2 Optional requirements

Requirements may be agreed upon by the interested parties for properties needed for particular applications (see table 4).

6 Test methods

6.1 General

6.1.1 Sampling

A sample sufficient to determine the compliance of the material with this specification shall be selected in accordance with ISO 2859 at random from each batch of the material.

6.1.2 Conditioning and testing atmospheres

Conditioning of specimens (48 h) and tests shall be carried out in accordance with ISO 291 at 23 ± 2 °C and (50 ± 5) % relative humidity, except for the Vicat softening point and the deflection temperature (see 6.6.1 and 6.6.2).

6.1.3 Preparation of test specimens

Test specimens shall be prepared in accordance with the procedures specified in ISO 2818, whenever applicable.

When it is necessary to machine the sheet to the thickness required for a particular test method, one original surface shall be left intact.

6.1.4 Specimen thickness

When the sheet has a thickness less than that required for the specimens by the relevant test method, specimens having the thickness of the sheet shall be used.

6.2 Appearance

Defects and their distribution shall be evaluated by inspecting the sheet illuminated by daylight or by a daylight-type fluorescent lamp with a colour temperature of $6\,500 \pm 650$ K and a power rating of not less than 40 W.

6.3 Colour

Colour differences between a reference material (standard) and the test samples shall be determined by methods agreed between the interested parties.

6.4 Dimensions

6.4.1 The length and width shall be measured to the nearest 0,5 mm in accordance with 4.4.3, using a calibrated rule.

6.4.2 The thickness shall be measured to the nearest 0,05 mm in accordance with 4.4.3, using a calibrated micrometer or dial-gauge. Measurements shall be carried out at not less than 100 mm from the sheet edge.

6.5 Mechanical properties

6.5.1 The flexural properties shall be determined in accordance with ISO 178. The original surface shall be put into tension whenever the specimen has been machined to conform with the specified dimensions. Specimens shall be cut so that they are oriented perpendicular to the machine direction (see also 6.1.4).

6.5.2 The tensile properties shall be determined in accordance with ISO 527, type 2 specimen, speed B. Specimens shall be cut so that they are oriented perpendicular to the machine direction (see also 6.1.4).

6.5.3 The impact strength (Charpy) shall be determined in accordance with ISO 179, using the standard small un-

notched bar ISO 179/1D (dimensions of specimen 80 mm × 10 mm × 4 mm) or ISO 179/2D (dimensions of specimen 50 mm × 6 mm × 4 mm). The pendulum shall strike the surface that is opposite to the original one if the specimen has been machined to the specified dimensions. Specimens shall be cut so that they are oriented perpendicular to the machine direction (see also 6.1.4).

6.5.4 The Rockwell hardness shall be determined in accordance with ISO 2039-2, scale M, on the original melt-calendered extruded surface.

6.6 Thermal properties

6.6.1 The Vicat softening point shall be determined in accordance with ISO 306, method B, using the original melt-calendered extruded surface. The rate of heating shall be 50 ± 5 K/h. Before the test, the specimens shall be conditioned for 16 h at 80 ± 2 °C and cooled to room temperature in a desiccator.

6.6.2 The deflection temperature under load shall be determined in accordance with ISO 75, method A. Specimens shall be cut so that they are oriented perpendicular to the machine direction (see also 6.1.4). Before the test, the specimens shall be conditioned for 16 h at 80 ± 2 °C and cooled to room temperature in a desiccator. Measurements shall not be carried out on specimens with thicknesses below 3 mm.

6.6.3 The dimensional change during heating (shrinkage) shall be determined by the method described in annex B.

6.6.4 The linear expansion coefficient shall be determined in accordance with EN 2155-12.

6.7 Flammability

Flammability and burning properties shall be determined in accordance with national fire regulations.

6.8 Optical properties

6.8.1 The light transmittance shall be determined using "Illuminant C" in accordance with EN 2155-5.

6.8.2 Haze shall be determined in accordance with EN 2155-9.

6.8.3 The light transmittance at 402 nm, before and after exposure for 1 000 h to a xenon lamp in accordance with ISO 4892, shall be determined in accordance with annex A. By agreement between the interested parties, the light transmittance may alternatively be determined after exposure to a carbon arc lamp.

6.8.4 The refractive index shall be determined in accordance with ISO 489, method A.

6.9 Other properties

6.9.1 The density shall be determined in accordance with ISO 1183, method A, C or D.

6.9.2 The water absorption shall be determined in accordance with ISO 62, method 1 (24 h at 23 °C).

6.9.3 The natural weathering performance shall be determined in accordance with ISO 4607; the resistance to exposure

to artificial light shall be determined in accordance with ISO 4892. Changes in colour and properties after exposure shall be determined in accordance with ISO 4582. The details of these tests shall be agreed upon by the interested parties.

6.9.4 The viscosity number shall be determined in accordance with ISO 1628-6.

6.9.5 The melt flow rate shall be determined in accordance with ISO 1133, condition No. 13 (test temperature 230 °C, nominal load 3,8 kg).

Table 3 — Basic properties of PMMA melt-calendered extruded sheets — Range of values

Property	Unit	Test method	Range of values	Sub-clause
Tensile strength	MPa	ISO 527, type 2 specimen, speed B	60 to 76	6.5.2
Modulus of elasticity in tension	MPa	ISO 527, type 2 specimen, speed B	2 900 to 3 100	6.5.2
Elongation at break	%	ISO 527, type 2 specimen, speed B	2 to 5	6.5.2
Impact strength (Charpy unnotched)	kJ/m ²	ISO 179	8 to 10	6.5.3
Vicat softening temperature	°C	ISO 306, method B (5 kg)	88 to 112	6.6.1
Dimensional change (shrinkage) at elevated temperature ¹⁾				
Thickness, <i>t</i> (mm)				
1,5 < <i>t</i> < 2	%	Annex B	10 to 20	6.6.3
2 < <i>t</i> < 2,5	%	Annex B	6 to 18	6.6.3
2,5 < <i>t</i> < 3	%	Annex B	6 to 12	6.6.3
3 < <i>t</i> < 6	%	Annex B	3 to 10	6.6.3
6 < <i>t</i>	%	Annex B	3 to 10	6.6.3
Melt flow rate	g/10 min	ISO 1133, condition No. 13 (230 °C, 3,8 kg)	0,5 to 3	6.9.5
Viscosity number	ml/g	ISO 1628-6	55 to 88	6.9.4
Light transmittance at 330 to 780 nm (thickness 3 mm) ²⁾	%	EN 2155-5	90 to 91	6.8.1
Light transmittance at 420 nm (thickness 3 mm) ²⁾				
— before exposure to xenon lamp (ISO 4892)	%	Annex A	90 to 91	6.8.3
— after exposure to xenon lamp for 1 000 h (ISO 4892)	%	Annex A	88 to 89	6.8.3

1) Specimen cut perpendicular to the machine direction.

2) For transparent colourless materials.

Table 4 — Optional requirements for PMMA melt-calendered extruded sheets — Range of values

Property	Unit	Test method	Range of values	Sub-clause
Flexural strength	MPa	ISO 178	100 to 115	6.5.1
Rockwell hardness (M scale)		ISO 2039-2	90 to 95	6.5.4
Linear expansion coefficient	K ⁻¹	EN 2155-12	$7 \times 10^{-5}^{2)}$	6.6.4
Temperature of deflection under load	°C	ISO 75, method A (1,8 MPa)	80 to 101	6.6.2
Haze	%	EN 2155-9	0,5 to 2	6.8.2
Refractive index, n_D^{20}		ISO 489, method A	1,493 ²⁾	6.8.4
Density ¹⁾ (clear)	g/cm ³	ISO 1183, method A, C or D	1,19 ²⁾	6.9.1
Water absorption	mg	ISO 62, method 1 (24 h, 23 °C)	50 ²⁾	6.9.2

1) Coloured sheet may have a higher value.

2) Typical values.

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Annex A

Determination of light transmittance at 420 nm

(This annex forms an integral part of the Standard.)

A.1 Apparatus

The instrument used for this determination is a spectrometer.

The light source of the spectrometer shall produce a continuous light spectrum in the range of wavelengths between 380 and 700 nm (tungsten lamp).

The wavelength accuracy shall be ± 3 nm and the reproducibility ± 2 nm.

A.2 Test specimens

Three specimens shall be cut from the sheets and cleaned. The dimensions of the specimens shall be compatible with the spectrometer utilized for the measurement. The measurement shall give the total transmittance of a surface area of at least 1 cm².

A.3 Procedure

The measurement shall be made in the optical axis normal to the specimen.

Before the measurement, calibrate the spectrometer in accordance with the manufacturer's instructions.

Place the specimen in the instrument and read the value of the transmittance at the wavelength of 420 nm.

A.4 Test report

The test report shall include the following :

- a) the transmittance at 420 nm;
- b) the thickness of the test specimen.

Annex B

Determination of dimensional change (shrinkage) at elevated temperature

(This annex forms an integral part of the Standard.)

B.1 Cut three square test specimens of side 100 ± 2 mm from the sample sheet at positions approximately equally spaced across the width of the sample. Mark on the test specimens the machine direction. Dry the test specimens at 70 ± 2 °C for 48 h and then allow them to cool to room temperature (18 to 28 °C; in case of dispute 23 ± 2 °C) in a desiccator. Mark the four sides and measure them to the nearest 0,02 mm.

B.2 Place the test specimens horizontally on a plane plate on a shelf in an oven maintained at 160 ± 2 °C. To avoid sticking of the specimens, cover the supporting plate with a layer of talc. The heating time, depending on the thickness of the sheet, shall be as follows :

Thickness, mm	Time, min
1,5 to 5	60
> 5	75

B.3 Allow the test specimens to cool to room temperature (18 to 28 °C; in case of dispute 23 ± 2 °C) in a desiccator and measure the four sides again to the nearest 0,02 mm.

B.4 Calculate the change in length of each side of each test specimen as a percentage of the initial value. Calculate the average percentage change parallel to and perpendicular to the machine direction for each test specimen and the average values for the set of three specimens.

B.5 Report the presence of bubbles or cracks, and any other change in the appearance of the test specimens.

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